LCM-39420

Current Source/TE Controller Module

Instruction Manual

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IMPORTANT

The LCM-39420 module requires LDC-3900 firmware version 2.5 or greater. Usage with previous versions of firmware may produce unpredictable results.

1.0 Introduction

The LCM-39420 Current Source/TE Controller Module is a precision laser controller (current source and temperature controller) module for use in the LDC-3900 Modular Laser Diode Controller. It may be installed in any of the four bays at the rear of the LDC-3900 (and may readily be interchanged with any other LDC-3900 module).

Features of the LCM-39420 include:

- Service-free modularity (calibration information is stored on the LCM-39420)
- Closed-case calibration
- High-stability, low noise design
- Flexible setup with LDC-3900 Save/Recall front panel functions
- Photodiode feedback control mode

2.0 LCM-39420 Specifications

Current Source[1]

Set Point Accuracy:	±100 µA
Set Point Resolution:	10 µA
Compliance Voltage (fixed):	5 V maximum
Temperature Coefficient:	< 100 ppm/°C
Stability[2], for 1 hour:	< 25 ppm
Stability[3], for 24 hours:	< 50 ppm
Noise and Ripple[4]	
Low Bandwidth Mode:	< 2.5 µA rms
CW Mode (with 320 cable)[5]:	< 1 µA rms

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[1] All values relate to a one-hour warm-up period.

[2] Over any 1-hour period, half-scale output.

[3] Over any 24-hour period, half-scale output.

[4] Measured from resulting intensity fluctuations of a laser diode, measured optically with a 150 kHz bandwidth photodetector. Measurements made with 1 MHz detector are typically 10% higher. For more information refer to ILX Noise and Transient Test Standards publication.

39420 Laser Current Source Specifications (continued)

Voltage Measurement Range:	0 to 7 V
Voltage Measurement Accuracy:	±2 mV
Worst Case Transients	
Operational[6]:	<1 mA
Power-Line induced[7]:	<1 mA

Photodiode Feedback

Range:	20 to 2000 µA
Output Stability[8]:	±2 µA
Accuracy:	±2 µA

Laser Drive Current Display

Output Current Range:	0.00 to 200.00 mA
Output Current Resolution:	0.01 mA
Output Current Accuracy at 25°C:	±0.1 mA
Photodiode Current Range:	0 - 2,000 µA
Photodiode Current Resolution:	1 µA
Photodiode Current Accuracy:	±2 µA
Responsivity Range:	0 - 1000.00 µA/mW
Responsivity Resolution:	0.01 µA/mW
Optical Power Range:	0 - 200.00 mW
Output Power Resolution:	10 µW
Type:	5-digit green LED

Current Limit Setting

Range:	0 - 200 mA
Resolution:	1 mA
Accuracy:	±2 mA

Output Connectors

Current Source Output:	9-pin, D-sub

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[5] If lower noise performance is required, ILX Lightwave model 320 low-noise filter option may be used. Note however, that this filter greatly reduces the effectiveness of the intermittent-open-circuit transient protection of the current source, and all cable connections and solder joints should be robust and tightly secured.

[6] Maximum output current transient resulting from normal operational situations (e.g., power on-off), as well as accidental situations (e.g., power line plug removal). For more information refer to ILX Noise and Transient Test Standards publication.

[7] Maximum output current transient resulting from a 200V power line transient spike. For more information refer to ILX Noise and Transient Test Standards publication.

[8] Maximum monitor photodiode current drift over any 30 minute period. Constant-power mode stability specification assumes zero drift in detector responsivity.

2.1 LCM-39420 TEC Specifications[9]

TEC Output[10]

Output Type:	Bipolar constant current source
Compliance Voltage:	>4 Volts
Maximum Current Output:	2 Amps
Maximum Output Power[11] :	8 Watts typical
Current Limit Control Range:	0 - 2A
Current Limit Accuracy:	±50 mA
Ripple / Noise[12] :	< 1 mA rms

TEC Display

Display Type:	5-digit green LED display
Maximum Current Reading:	2.000 Amps
Maximum Temp Reading:	999.9 °C
Current Resolution:	0.001 Amps
Current Display Accuracy:	±0.04 Amps
Temperature Resolution:	0.1 °C
Temperature Display Accuracy:	±0.5 °C
Thermistor Resistance Resolution:	0.01 kΩ at 10 µA setting; 0.001 kΩ at 100 µA setting
Thermistor Resistance Display Accuracy:	±0.05 kΩ at 10 µA setting ±0.005 kΩ at 100 µA setting

Temperature Control

Temperature Range[13] :	-99 °C to +199 °C -20 °C to +70 °C with typical 10K thermistor	
Thermistor Control[14]	Resolution	Accuracy
-20 °C to 20°C:	0.1 °C	±0.2 °C
50 °C:	0.2 °C	±0.2 °C
Short Term Stability[15] :	±0.05 °C or better, over 1 hour	
Long Term Stability[16] :	±0. 1 °C or better, over 24 hours	

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[9] All values relate to a one-hour warm-up period.

[10] Output current and power are rated into a one ohm load.

[11] Higher output powers can be accommodated by using a booster. Contact ILX Lightwave for further information.

[12] Broadband noise is measured at 1A output current over a bandwidth of 10 Hz - 10 MHz.

[13] Temperature control range depends primarily on the type of thermistor and TE module used. The range can be extended higher and lower by selecting appropriate components. See Appendix B for more details.

[14] Accuracy figures quoted are typical for a 10 KOhm thermistor. Accuracy figures are relative to calibration standard. Both resolution and accuracy are dependent on the user defined configuration of the instrument.

[15] Over any 1 hour period at 25 °C. Short term temperature stability is a strong function of the thermal environment of the thermistor and TE module. Room air currents in particular can easily cause fluctuations of 0.1 °C in an exposed mounting configuration.

[16] Over any 24 hour period, at 25 °C.

Temperature Control (cont.)

Sensor Type:	2-wire thermistor
Usable Thermistor Range:	25 Ω to 450 kΩ, typ.
Thermistor Sensing Current:	10 μA or 100 μA (user selectable)
Temperature Calculation Method:	Thermistors are calibrated by storing three constants of the Steinhart-Hart equation in internal non-volatile memory.

$$1/T = (C1 * 10^{-3}) + (C2 * 10^{-4})(\ln R) + (C3 * 10^{-7})(\ln R)^3 \quad (T \text{ in Kelvin})$$

3.0 Installation

This section describes the procedures for installing and removing a LCM-39420 module from the LDC-3900.

> **NOTE - The LDC-3900 will power-up in a default state upon detecting any change in the LDC-3900 system configuration (such as installing a new module). All parameters and SAVE/RECALL settings will be set to default values, based on the new configuration. Calibration data is stored in the LCM-39420 module itself, and is never lost due to reconfiguration of the LDC-3900.**

To install the LCM-39420 module into the LDC-3900, follow these steps:

1. **Turn the LDC-3900 power off.**

2. Place the LCM-39420 module into an open bay on the back of the LDC-3900 and slide the module into place. There are tracks at the top and bottom of the bay which guide the module into place. Push the module into place until the board edge clicks into place with an audible "pop." This indicates that the module is "locked" into place. Fasten module to the mainframe with the Module Locking Screws (see Figure 4.1) to secure the module. It is then ready to be used in the LDC-3900.

3. Power-up the LDC-3900.

4. After the LDC-3900 has completed its power-up sequence, the (ADJUST) LAS and TEC indicators which correspond to the newly installed LCM-39420 module should be lit in green, indicating that the module has been recognized as a LASER controller in its respective bay.

To remove the LCM-39420 module from the LDC-3900, follow these steps:

1. **Turn the LDC-3900 power off.**

2. Unfasten the Module Locking Screws (see Figure 4.1) on the LCM-39420 module back panel.

3. Grasp the LCM-39420 module by the handle which extends from the bottom of the back panel. Gently, but firmly, pull the module out of the LDC-3900.

4. If the LCM-39420 module is replaced in the LDC-3900 before the LDC-3900 is powered up again, the LDC-3900 will retain its memory of all parameter settings and SAVE/RECALL values. However, if the LDC-3900 is powered up and detects a change in its system configuration, all parameters and SAVE/RECALL information will be lost. Calibration data is stored in the LCM-39420 module itself, and is never lost due to reconfiguration of the LDC-3900.

4.0 Operation

This section describes the procedures for connecting and running a laser diode with the LCM-39420 module. Refer to Chapter 2 of the LDC-3900 Instruction Manual for front panel description and operation.

Refer to Figure 4.1 for the following discussion of connections to the LCM-39420.

NOTE - The LCM-39420 module only operates with both the TEC and LASER outputs turned on or off together.

If you wish to run the LCM-39420 current source with no temperature control, the TEC output must be shorted (or a dummy load connected) to pins 1/2 and 3/4 of the TEC connector. Also, a sensor load resistor (i. e. 10K Ohms) must be connected between pins 7 and 8 (see Figure 4.4).

If you wish to run the LCM-39420 TEC controller with no laser (current) output, the LAS interlock pins 1 and 2 must be shorted. Also, the LAS output pins 4/5 and 8/9 must be shorted (see Figure 4.2).

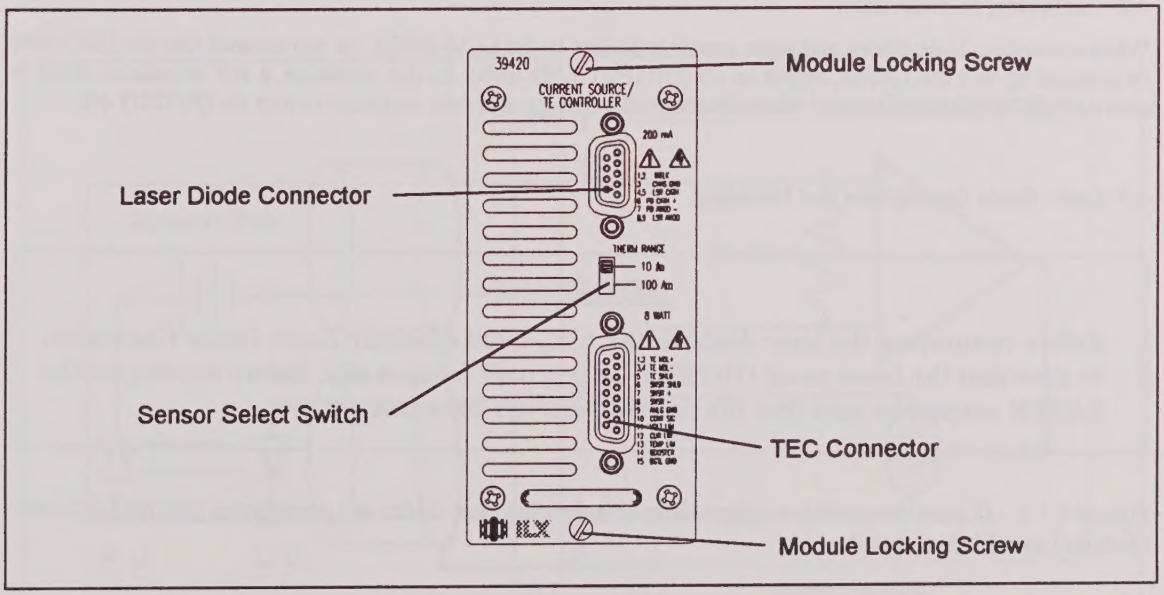

Figure 4.1 LCM-39420 Back Panel

When operating the LCM-39420 module, note the following differences from a standard module in the LDC-3900 front panel operation:

- Pressing the ADJUST switch will toggle between LAS adjust, TEC adjust and none.
- The (OUTPUT) ON switch turns both the LAS and TEC outputs on or off together. They are always both on or off.
- The (LASER MODE) SELECT switch toggles between I and P modes (I_{HBW} mode is not available on the LCM-39420).

4.1 The LASER Connector

On the back panel of the LCM-39420 you will find a 9-pin D-connector for the LD connections. The pinout diagram for this connector is shown in Figure 4.2.

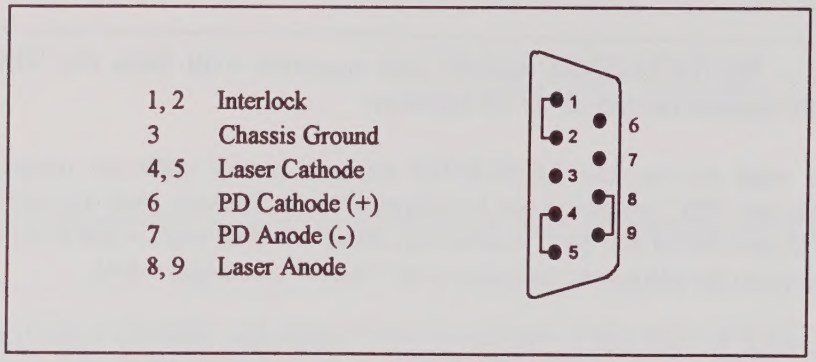

Figure 4.2 Back Panel LD Connector

4.2 Connecting to Your Laser

When connecting laser diodes and other sensitive devices to the LCM-39420, we recommend that the LDC-3900 be powered up and the LASER output be off (OUTPUT LED unlit). In this condition, a low impedance shunt is active across the output terminals. When disconnecting devices, it is only necessary to turn the OUTPUT off.

4.3 Laser Diode Connections and Shielding

IMPORTANT

Before connecting the laser diode to the LDC-3900 Modular Laser Diode Controller, be sure that the front panel OUTPUT LED is unlit (output off). Before turning on the LASER output, be sure that the current limit has been correctly set.

Figures 4.3 A - D show the possible configurations of connecting laser diodes and photodiodes with the LDC-3900 Modular Laser Diode Controller.

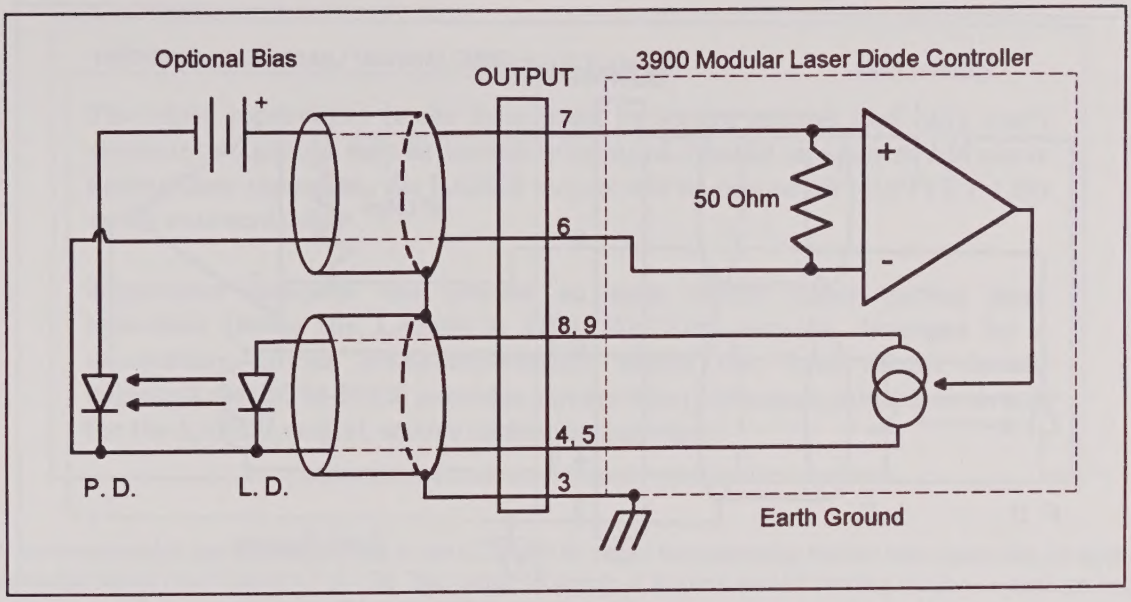

Figure 4.3A Common Laser Cathode - Photodiode Cathode

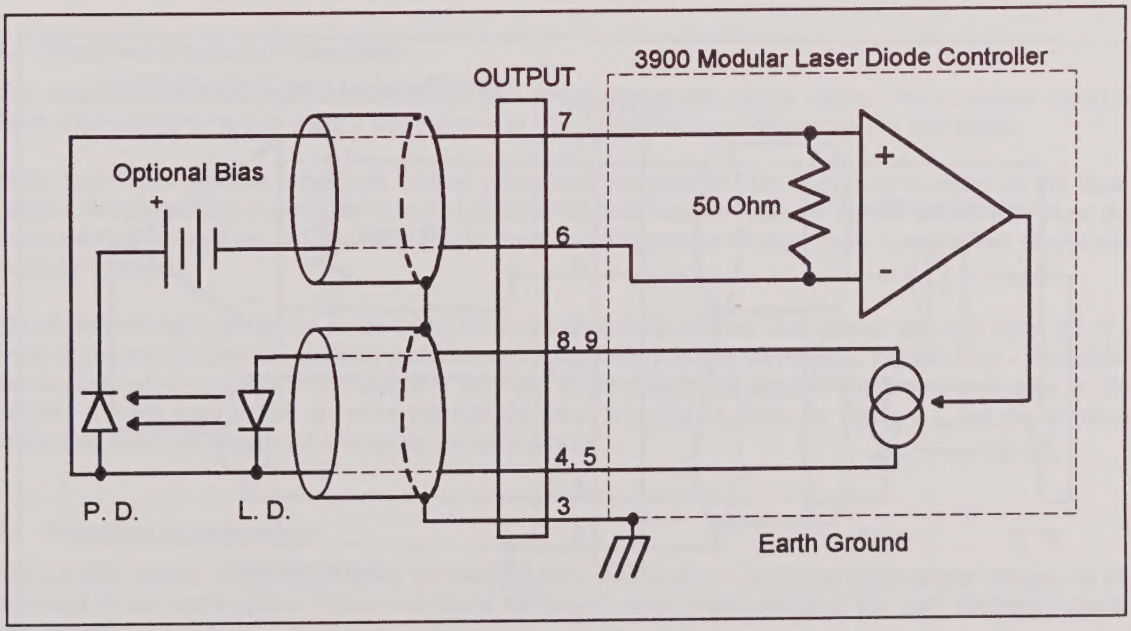

Figure 4.3B Common Laser Cathode - Photodiode Anode

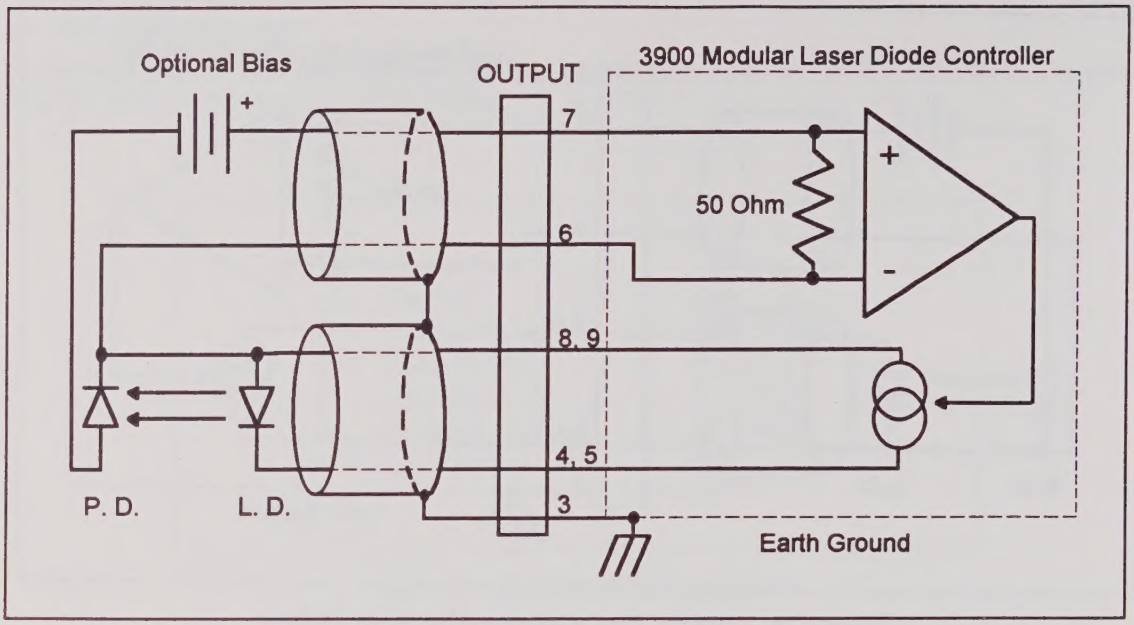

Figure 4.3C Common Laser Anode - Photodiode Cathode

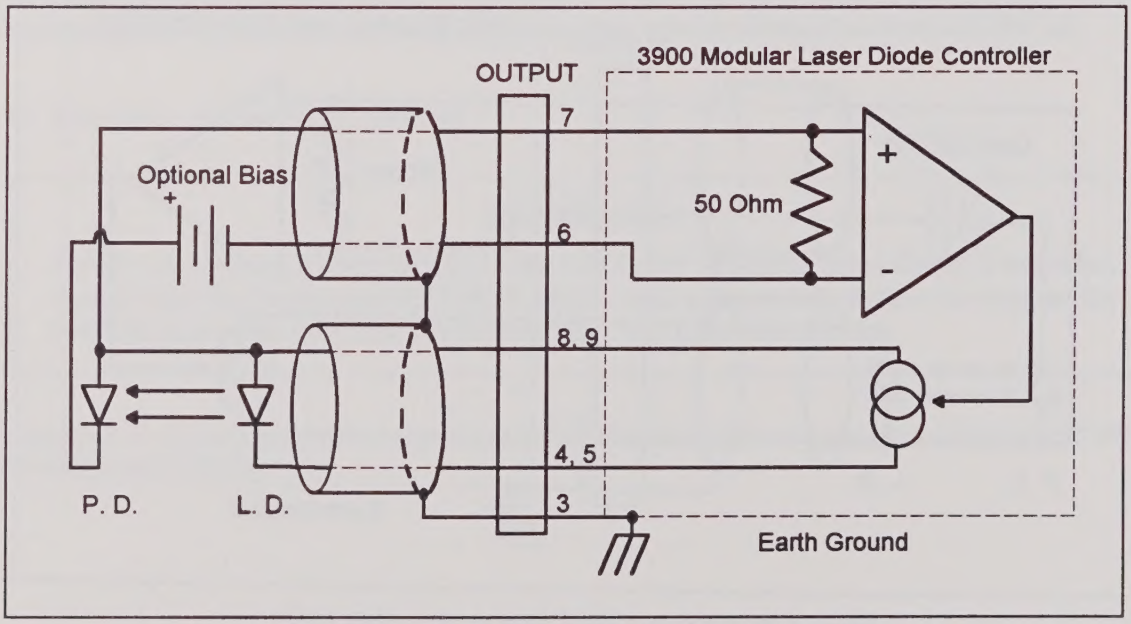

Figure 4.3D Common Laser Anode - Photodiode Anode

IMPORTANT

The cable connections to the laser must be secure enough that they won't open-circuit, should they be jostled or bumped. Should an open circuit occur during laser operation, the LASER output will be turned off (OUTPUT LED unlit) automatically.

Experience indicates that should an open circuit occur during laser operation (while the LASER is ON), the laser may be damaged by a momentary circuit break-and-remake before the final circuit break. Although the LCM-39420 provides a proprietary debounce protection circuit for the LASER output, secure cabling is important.

It is recommended that the connections to the LCM-39420 output be made using twisted wire pairs with an earth-grounded shield (see Figures 4.3 A - D). The output terminals of the unit are left floating relative to earth ground to suppress AC power-on/power-off transients that may occur through an earth-ground path. If the output circuit is earth-grounded at some point (such as through the laser package and mount), the user must be careful to avoid multiple earth grounds in the circuit. Multiple earth grounds may provide circuit paths that induce spurious currents in the photodiode feedback circuit and output leads.

4.4 Photodiode Feedback Connections

The connector on the back panel of the LCM-39420 contains the current supply output. The photodiode signal is input at the connector at pins 6 and 7 (see Figure 4.2). The LCM-39420 photodiode input is zero biased.

Many laser diode modules contain an internal photodiode that monitors the back-facet emission of the laser. Usually, this photodiode is internally connected to either the laser anode or cathode. Figures 4.2A - 4.2D show the recommended connections and shielding for the various configurations of laser diode modules and photodiode feedback schemes.

The photodiode and laser inputs on the LCM-39420 are electrically isolated from ground and each other. So, if a 4-pin connection is made (no common connections) no additional jumpers are required. Figures 4.2A - 4.2D show the recommended connections and shielding for 3-pin lasers (where the common connection is internal to the device). A 4-pin laser should be connected with the same shielding as shown in Figure 4.2, but the common connection (between the photodiode and the laser) is optional.

4.5 Grounding Considerations

The LASER outputs of the LCM-39420 are isolated from chassis ground allowing either output terminal to be grounded at the user's option. Figure 4.3 shows the proper earth-ground shielding for laser diode/photodiode connections.

4.6 SENSOR SELECT Switches

The THERM RANGE switch is used to select the thermistor source current level. Table 4.1 shows the THERM RANGE positions and corresponding position code. When the THERM RANGE switch is changed during TEC mode operation, the new sensor position code will be indicated on the TEC display for three seconds.

SENSOR SELECT POSITION CODES

SWITCH POSITION	CODE
100 μA	–01
10 μA	–02

Table 4.1 SENSOR SELECT Switch Positions

The 10 μA and 100 μA designations are for the thermistor current level; thermistor sensor type is implied. When using a thermistor, the thermistor supply current depends on the thermistor operating temperature range and the required temperature resolution. Guidelines for setting this switch are contained in Appendix B.

4.7 The TEC Connector

On the LCM-39420 back panel, you will find the 15-pin D-connector for the TEC MODULE. This connector is used for the input and output connections, as shown by the pin-out diagram of Figure 4.4.

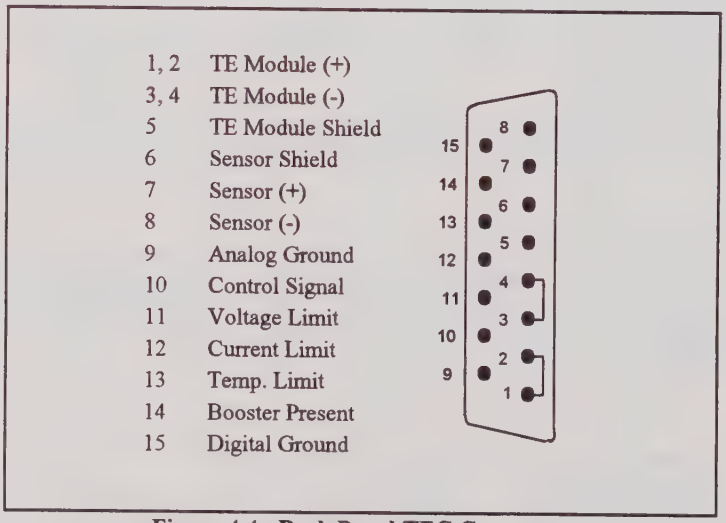

Figure 4.4 Back Panel TEC Connector

4.8 TEC Grounding Considerations

The TEC outputs of the LCM-39420 are isolated from chassis ground (as well as the laser current outputs), allowing either output terminal to be grounded or connected to the laser, at the user's option.
********NOTE: FOR the TEC connector, if any one terminal pin is grounded, then NO OTHER terminal pin should be grounded. Damage to external unit or Temperature Controller will occur.**********

4.9 TEC Interlock

On the back panel TEC connector, pins 13 (TEMP LIMIT) and 15 (DIGITAL GND) form a type of interlock. These two pins are normally not connected (open circuit), and must remain open for the TEC output to be on. If there is a short circuit between these pins the TEC output will be disabled. When this short circuit is present, the TEC Interlock Error condition/event will be reported in the TEC Event Status Register and the TEC Condition Status Register.

This circuit is useful for remote monitoring of temperature, and therefore is labeled TEMP LIMIT on the back panel connector. This interlock is intended for use with an external current booster. A switch or control circuit of the user's own design is required. It is left as an option which the user may or may not employ.

4.10 Booster Operation

The LCM-39420 may be used to control a booster current source which accepts a control signal of up to ±10.0 volts. A booster current source may be required if the LCM-39420's 8 Watt output is not adequate to control a thermal load.

Whenever a connection is present between the BOOSTER PRESENT (pin 14) and DIGITAL GROUND (pin 15) of the back panel TEC Input/Output connector, the (BOOSTER) CONTROL SIGNAL (pin 10) voltage will be available for controlling a booster TEC current source, see Figure 4.4.

The Booster Enabled condition is reported in the TEC Condition Status register. When the GPIB option is implemented, this condition may be used to trigger a service request.

The booster current source should use the control voltage which is available between the (BOOSTER) CONTROL SIGNAL (pin 10) and ANALOG GND (pin 9) of the back panel TEC connector, see Figure 4.4.

When the BOOSTER PRESENT signal is connected to DIGITAL GROUND, the LIM I value may be increased above the normal operation maximum of 2.0 Amps, to a maximum of 10.0 Amps. This is permitted for operation with a booster current source so that the CONTROL SIGNAL voltage may be ±10.0 volts. The CONTROL SIGNAL voltage is linearly proportional to the control current, which is limited by the LIM I parameter.

Whether or not a booster current source is used, the LCM-39420 uses a sensor for controlling the temperature. The feedback loop GAIN may require adjustment when a booster current source is used. This is because a booster current source may be used with different thermal loads than those found with normal LCM-39420 operation, and those loads may require larger or smaller GAIN values in order to settle to the set temperatures in a desirable fashion. See Section 2.10.6 of the LDC-3900 Instruction Manual for setting the GAIN value.

During operation, if the status of the connection between the BOOSTER PRESENT and DIGITAL GROUND changes, this event will be reported in the TEC Event Status Register. When the GPIB option is implemented, this event may be used to trigger a service request.

5.0 Calibration

The LCM-39420 should be calibrated every 12 months or whenever performance verification indicates that calibration is necessary.

All calibrations can be done with the case closed. The instrument is calibrated by changing the internally stored digital calibration constants.

5.1 Recommended Equipment

Recommended test equipment for calibrating the LCM-39420 is listed in Table 5.1. Equipment other than that shown in the table may be used if the specifications meet or exceed those listed. If your LDC-3900 is equipped with the model 1231 GPIB/IEEE-488.2 interface you may refer to sections 5.4.2, 5.4.4, 5.4.6, 5.5.2, and 5.5.4 for calibration procedures using the GPIB, if desired.

RECOMMENDED TEST EQUIPMENT

Description	Mfg./Model	Specification
DMM	HP 3457A	0.1 µA or 0.1 mV resolution DC Amps (@ 1.0 A): ±1 % Resistance (@ 10 Ω): 0.02 %
Resistor		49 Ω, 5 W, low TCR, for voltage cal.
I_{PD} Calibration		
Resistors	Metal Film	49 Ω, and 100 Ω, 1%, 1/4 W
	High-power	11 Ω, 5 W, low TCR
Optical Isolator	TIL117	or equivalent, 6-pin
Connector	D-sub	9-pin male
Battery		9 volts
TEC Calibration		
Resistors	Metal Film	10 KΩ for 100 µA calibration 100 KΩ for 10 µA calibration
	High-Power	1 Ω, 10 W, low TCR, for current calibration

Table 5.1 Recommended Test Equipment

5.2 Environmental Conditions

Calibrate this instrument under laboratory conditions. We recommend calibration at 23°C ± 1.0°C. When necessary, however, the LCM-39420 may be calibrated at its intended use temperature if this is within the specified operating temperature range of 0 to 50°C.

5.3 Warm-Up

The LDC-3900 should be allowed to warm up for at least 1 hour before calibration.

Note - For all calibration procedures (except thermistor calibration) a proper load must be present on <u>both</u> the LASER and TEC output connectors. This is because both outputs are always turned on and off together.

Calibration procedures may be aborted with no ill effect by powering off the LDC-3900 before the last value is entered for any calibration procedure.

5.4 LASER Controller Calibration Procedures

There are three calibration procedures that need to be made for the LCM-39420. They are calibration of the constant current source, calibration of the laser voltage measurement, and calibration of the constant light power (I_{PD}) feedback circuits.

The LCM-39420 implements a two-point calibration for the Laser current source. Two currents are applied to a load, and the resulting measured currents are fed back (by the user) to the LCM-39420. The LCM-39420 calibration program uses the two data points to calculate calibration constants that it will thereafter use to set current.

If you have the optional Model 1231 IEEE-488.2/GPIB interface you may follow the procedure in sections 5.4.2, 5.4.4, and 5.4.6 to calibrate the LCM-39420 remotely.

5.4.1 Local Operation Current Source Calibration

The following procedure is for local (front panel) operation. See Section 5.4.2 for remote calibration of the current source. At the end of this procedure, the instrument will automatically calibrate the current limit.

a. Select the LCM-39420 to be calibrated by pressing the appropriate (ADJUST) LAS/TEC switch until the LAS indicator is orange. Set the LASER current limit (LIM I) to 180 mA (90% of full scale), and current set point to 160 mA (80% of full scale). Connect a calibrated DMM to measure the current across the output (pins 5 and 8).

b. Turn the (LASER ENABLE) ON switch and press the appropriate (OUTPUT) ON switch to turn the LASER output on. If the LASER output is not on, the LASER I calibration mode cannot be entered. If the LASER output is on, but the LASER channel is not selected (see Step a), calibration will be performed improperly.

c. Enter the LASER I calibration mode by pushing the (GPIB) LOCAL and (LASER DISPLAY) I switches at the same time. The LASER display will indicate output current in mA. The LDC-3900 will beep when it is ready to accept a new calibration value.

d. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current as measured via the DMM.

e. Release the (PARAMETER) SET switch to accept the first calibration value. After the (LASER DISPLAY) SET switch is released, the LDC-3900 will beep. It will then apply the second calibration current, approximately one-fourth of the original current.

f. The LDC-3900 will beep when it is ready to accept the second calibration value. When it does, press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current as measured via the DMM.

g. Release the (PARAMETER) SET switch to accept the second calibration value. After the (PARAMETER) SET switch is released, the LDC-3900 will perform a limit calibration, then calculate the calibration constants, store them to nonvolatile memory on the LCM-39420, beep, and return to its former (before calibration) state after about 15 seconds.

5.4.2 Remote Operation Current Source Calibration

The following procedure is for remote (GPIB) operation. See Section 5.4.1 for local calibration of the current source.

a. Select the LCM-39420 to be calibrated by sending the "LAS:CHAN x" command, where x is the channel of the LCM-39420. Set the LASER limit to 90% of full scale via the "LAS:LIM:I 180" command, and current set point to 80% of full scale via the "LAS:LDI 160" command. Connect a calibrated DMM to measure the current across the laser output (pins 5 and 8).

b. Turn the (LASER ENABLE) ON switch. Enter the "LAS:OUT ON" command to turn the LASER output on. If the LASER output is not on, the LASER I calibration mode cannot be entered. (The TEC output will also be on.)

c. Enter the LASER I calibration mode by issuing the "LAS:CAL:LDI" command. The LDC-3900 will beep when it is ready to accept the first calibration point.

d. Input the first actual (measured) LASER output current (as an <nrf value>) via the "LAS:LDI <nrf value>" command.

   If this value is to be measured and entered remotely via a GPIB controlled DMM, for example, the measured value of the current should not be entered until the LDC-3900 is ready to receive it.

   The LDC-3900 will be ready to receive the current value when, after a "LAS:CAL:LDI?" query is sent, the response from the LDC-3900 is "1". This query should be issued every 1 - 3 seconds. The instrument should be ready for calibration in about 1 - 2 seconds.

e. Once the actual I value is entered via the "LAS:LDI" command, the LDC-3900 will beep and will apply a new current equal to approximately one-fourth (1/4) the previous set current. The LDC-3900 will be ready to receive the second current value when, after a "LAS:CAL:LDI?" query is sent, the response from the LDC-3900 is "1".

f. Input the second actual (measured) LASER output current (as an <nrf value>) as in Step d.

g. Once the second actual I value is entered via the "LAS:LDI" command, the LDC-3900 will beep, a limit calibration will be performed, and then the new calibration constants will be calculated and stored into non-volatile memory on the LCM-39420. The "OPC?" query may be used (after the "LAS:LDI" value is sent) to determine when the calibration is completed. This will take about 15 seconds to complete.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

5.4.3 Local Operation I_{PD} Current Calibration

The following procedure is for calibrating the LASER I_{PD} constant current source. This procedure calibrates the feedback circuits for constant I_{PD} and constant P_{PD} modes. When these values are reached and are stable, the user enters the actual value of the current, as measured by an external DMM. The LCM-39420 then automatically calibrates the LASER feedback circuits.

This procedure is for local (front panel) operation. See Section 5.4.4 for remote calibration of the I_{PD} current.

a. Select the LCM-39420 to be calibrated by pressing the appropriate (ADJUST) switch until the LAS indicator is orange. With the LASER output off, connect a calibrated ammeter to the PD Anode output of the LCM-39420, and connect the circuit of Figure 5.1 to the LASER and PD outputs.

   If a calibrated ammeter (with 0.1 μA resolution) is not available, place a calibrated DMM (with 0.1 mV resolution) to measure the voltage across the resistor, R1, as shown in Figure 6.1. Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

   -where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. (A 4-point probe resistance measurement is recommended.)

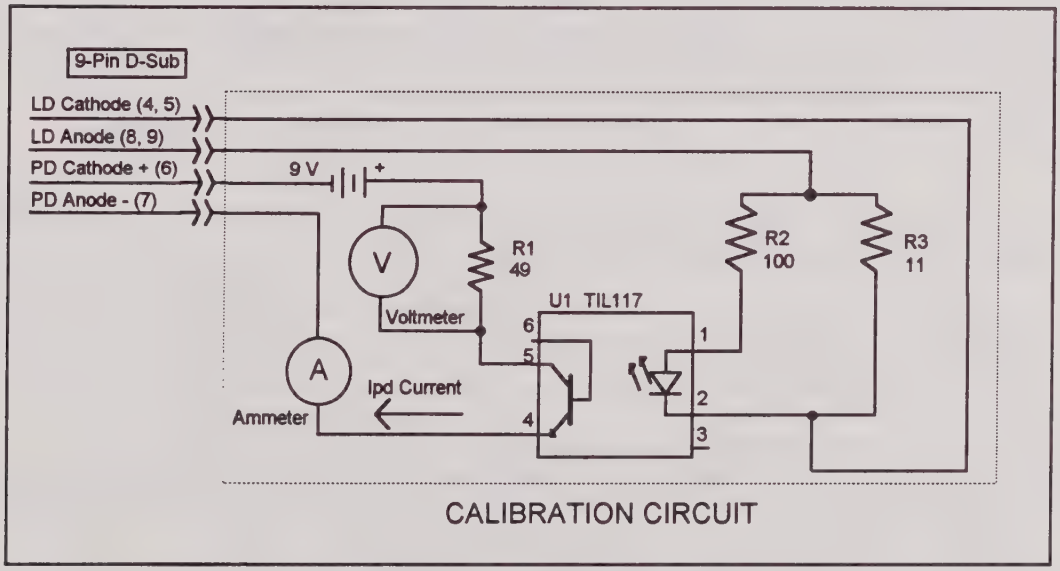

Figure 5.1 I_{PD} Calibration Circuit

b. Set the LASER current limit (LIM I) to 200 mA. Set the I_{PD} set point to 1600 μA, and set the CAL PD parameter to zero. This puts the LCM-39420 into a constant I_{PD} mode.

c. Turn the (LASER ENABLE) ON switch and press the appropriate (OUTPUT) ON switch to turn the LASER output on. (The TEC output will also be on.) If the LASER output is not on, the LASER I_{PD} calibration mode cannot be entered.

d. Press the (GPIB) LOCAL and (LASER DISPLAY) I_{PD}/P_{PD} switches at the same time to place the LCM-39420 in its LASER I_{PD} Calibration mode.

After a few seconds the LDC-3900 will beep and the LASER display will show the I_{PD} set point value.

e. After the value on the LASER display is stable (has not changed by more than one digit for several seconds) the LCM-39420 is ready for the actual I_{PD} value to be entered.

   Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display shows the correct value, as shown on the calibrated ammeter (or the calculated I_{PD} value from Step a).

f. Release the (PARAMETER) SET switch to store the first calibration value into non-volatile memory. It will then expect the second calibration current, approximately one-fourth of the original current.

g. The LDC-3900 will beep when it is ready to accept the second calibration value. When it does, press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current (as measured directly, or as calculated in Step a, from the measured voltage).

h. Release the (PARAMETER) SET switch to accept the second calibration point. After the (PARAMETER) SET switch is released, the LDC-3900 will calculate the calibration constants, store them to nonvolatile memory on the LCM-39420, beep, and return to its former (before calibration) state.

5.4.4 Remote Operation I_{PD} Current Calibration

The following procedure is for calibrating the LASER I_{PD} constant current source over GPIB. This procedure calibrates the feedback circuits for constant I_{PD} and constant P_{PD} modes. When these values are reached and are stable, the user enters the actual value of the current, as measured by an external DMM. The LCM-39420 then automatically calibrates the LASER feedback circuits.

This procedure is for remote (GPIB) operation. See Section 5.4.3 for local calibration of the I_{PD} current.

a. With the LASER output off, connect a calibrated ammeter to the PD Anode output of the LCM-39420, and connect the circuit of Figure 5.1 to the LASER and PD outputs.

   If a calibrated ammeter (with 0.1 μA resolution) is not available, place a calibrated DMM (with 0.1 mV resolution) to measure the voltage across the resistor, R1, as shown in Figure 5.1. Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

   -where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. (A 4-point probe resistance measurement is recommended.)

b. Select the LCM-39420 to be calibrated by sending the "LAS:CHAN x" command, where x is the channel of the LCM-39420. Set the LASER current limit via the "LAS:LIM:I 200" command. Set the I_{PD} set point to 1600 μA via the "LAS:MDI 1600" command. Set the CAL PD parameter to zero via the "LAS:CALMD 0" command. This puts the LCM-39420 into a constant I_{PD} (MDI) mode.

c. Turn the (LASER ENABLE) ON switch. Enter the "LAS:OUT ON" command to turn the LASER output on. (The TEC output will also be on.) If the LASER output is not on, the LASER I_{PD} calibration mode cannot be entered.

d. Enter the "LAS:CAL:MDI" command to place the LCM-39420 in its LASER I_{PD} Calibration mode.

e. After a few seconds, the LDC-3900 will be ready. Enter the first actual I_{PD} current value (as an <nrf value>) via the "LAS:MDI <nrf value>" command.

The measured value of the current should not be entered until the LDC-3900 is ready to receive it. The LDC-3900 will beep when it is ready to accept a new calibration value.

The LDC-3900 will be ready to receive the I_{PD} value when, after a "LAS:CAL:MDI?" query is sent, the response from the LDC-3900 is "1".

f. Once the actual I value is entered via the "LAS:MDI" command, the LDC-3900 will beep and the new calibration value will be stored into non-volatile memory. It will then set the current to approximately one-fourth of the original current and expect the second calibration value to be entered. The LDC-3900 will be ready to receive the second I_{PD} value when, after a "LAS:CAL:MDI?" query is sent, the response from the LDC-3900 is "1".

g. Input the second actual (measured) I_{PD} current (as an <nrf value>) as in Step e.

h. Once the second actual monitor diode current value is entered via the "LAS:MDI" command, the LDC-3900 will beep and the new calibration constants will be calculated and stored into non-volatile memory in the LCM-3900. The "OPC?" query may be used (after the "LAS:MDI" value is sent) to determine when the calibration is completed.

The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

5.4.5 Local Operation Laser Voltage Measurement Calibration

The following procedure is for calibrating the LASER voltage measurement via the front panel. See Section 5.4.6 for remote (GPIB) calibration of the voltage measurement.

a. With the LASER output off, connect a calibrated voltmeter, in parallel with a 49 Ω, 5 Watt, low temperature coefficient resistor, to the LASER output of the LCM-39420 (pins 5 and 8).

b. Select the LCM-39420 to be calibrated by pressing the appropriate (ADJUST) switch until the LAS indicator is orange. Set the LASER current limit (LIM I) to 200 mA. Set the LASER I set point to 100 mA.

c. Turn the (LASER ENABLE) ON switch and press the appropriate (OUTPUT) ON switch to turn the LASER output on. (The TEC output will also be on.) If the LASER output is not on, the LASER voltage calibration mode cannot be entered.

d. Press the (GPIB) LOCAL and (LASER DISPLAY) V switches at the same time to place the LCM-39420 in its LASER Voltage Calibration mode.

e. After a few seconds, the LDC-3900 will beep when it is ready to accept a new calibration value. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob to enter the LASER voltage measurement value which appears on the DMM. Release the (PARAMETER) SET switch to enter the value.

Once the actual voltage value is entered, the LDC-3900 will beep. It will then set the output to approximately one-fourth of the original voltage, and then it will expect the second calibration voltage point to be entered

f. Input the second actual (measured) LASER voltage (as an <nrf value>) as in Step e.

g. Once the second actual voltage value is entered, the LDC-3900 will beep and the new calibration constants will be calculated and stored into non-volatile memory on the LCM-39420.

5.4.6 Remote Operation Laser Voltage Measurement Calibration

The following procedure is for calibrating the LASER voltage measurement via GPIB. See Section 5.4.5 for local calibration of the voltage measurement.

a. With the LASER output off, connect a calibrated voltmeter, in parallel with a 49 Ω, 5 Watt, low temperature coefficient resistor, to the LASER output of the LCM-39420 (pins 5 and 8).

b. Select the LCM-39420 to be calibrated by sending the appropriate "LAS:CHAN x" command, where x is the channel number of the LCM-39420. Set the LASER current limit via the "LAS:LIM:I 200". Set the I set point via the "LAS:LDI 100" command.

c. Turn the (LASER ENABLE) ON switch. Enter the "LAS:OUT ON" command to turn the LASER output on. (The TEC output will also be on.) If the LASER output is not on, the LASER voltage calibration mode cannot be entered.

d. Enter the "LAS:CAL:LDV" command to place the LCM-39420 in its LASER Voltage Calibration mode.

e. After a few seconds, the LDC-3900 will be ready for the actual laser voltage to be entered (as an <nrf value>) via the "LAS:LDV <nrf value>" command. The measured value of the voltage should not be entered until the LDC-3900 is ready to receive it.

   The LDC-3900 will be ready to receive the voltage value when, after a "LAS:CAL:LDV?" query is sent, the response from the LDC-3900 is "1".

f. Once the actual voltage value is entered via the "LAS:LDV" command, the LDC-3900 will beep. It will then expect the second calibration voltage point, approximately one-fourth of the original voltage. The LDC-3900 will be ready to receive the second voltage value when, after a "LAS:CAL:LDV?" query is sent, the response from the LDC-3900 is "1".

g. Input the second actual (measured) LASER voltage (as an <nrf value>) as in Step e.

h. Once the second actual voltage value is entered via the "LAS:LDV" command, the LDC-3900 will beep and the new calibration constants will be calculated and stored into non-volatile memory on the LCM-39420.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

Note - For all calibration procedures (except thermistor calibration) a proper load must be present on <u>both</u> the LASER and TEC output connectors. This is because both outputs are always turned on and off together.

Calibration procedures may be aborted with no ill effect by powering off the LDC-3900 before the last value is entered for any calibration procedure.

5.5 TEC Calibration Procedures

There are two calibration procedures required for the TEC section of the LCM-39420. They are calibration of the resistance at the 10 microamp and the 100 microamp thermsitor source current settings, and calibration of the ITE current and limits.

5.5.1 Local Operation Thermistor Calibration

The following procedure is for calibrating the 100 μA and 10 μA thermsitor constant current sources so that the thermistor resistances for these ranges will be as accurate as possible. Use nominal values of 10 KΩ for the 100 μA setting and 100 KΩ for the 10 μA setting. This procedure is for local (front panel) operation. See Section 5.5.2 for remote calibration of the thermistor sensors.

a. Set the THERM RANGE switch on the back panel of the LCM-39420 to the 100 μA position. Select the LCM-39420 for calibration by pressing the appropriate (ADJUST) LAS/TEC switch (so that the TEC indicator is orange).

b. Measure and record the exact resistance of your metal film resistors. (A 4-point probe resistance measurement is recommended.) These resistors are very temperature sensitive (calibration can be impacted by the warmth of your fingers while holding the resistor). Attempt to measure the resistors and calibrate the instrument at the same temperature.

c. Connect the correct metal film resistor to the thermistor input of the LCM-39420 TE connector (pins 7 and 8, see Figure 4.1).

d. Enter the TEC sensor calibration mode by pushing the (GPIB) LOCAL and (TEC DISPLAY) R switches at the same time. The TEC display will become blank for 2 seconds, then the sensor code (SENSOR SELECT switch position) value will be displayed for 2 seconds. After this, the TEC display will indicate sensor resistance in KΩ. The LDC-3900 will beep when it is ready to accept a new calibration value.

e. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display indicates the same resistance you recorded for the metal film resistor.

f. Release the (PARAMETER) SET switch to store the new value into non-volatile memory on the LCM-39420. After the (PARAMETER) SET switch is released, the LDC-3900 will beep and return to its former state (before calibration).

g. Switch the THERM RANGE switch (back panel of the LCM-39420) to the 10 μA position and repeat this procedure with the other resistor.

5.5.2 Remote Operation Thermistor Calibration

The following procedure is for calibrating the 100 μA and 10 μA thermsitor constant current sources so that the thermistor resistances for these ranges will be as accurate as possible. Use nominal values of 10 KΩ for the 100 μA setting and 100 KΩ for the 10 μA setting. This procedure is for remote (GPIB) operation. See Section 5.5.1 for local calibration of the thermistor sensors.

a. Set the THERM RANGE switch on the back panel of the LCM-39420 to the 100 μA position.

b. Measure and record the exact resistance of your metal film resistors. (A 4-point probe resistance measurement is recommended.) These resistors are very temperature sensitive (calibration can be impacted by the warmth of your fingers while holding the resistor). Attempt to measure the resistors and calibrate the instrument at the same temperature.

c. Connect the correct metal film resistor to the LCM-39420 thermistor input (pins 7 and 8, see Figure 4.1). Use nominal values of 10 KΩ for the 100 μA setting and 100 KΩ for the 10 μA setting.

d. Enter the "TEC:CHAN x" command over the GPIB to select the channel of the LCM-39420 to be calibrated, where x = the channel number.

   Enter the "TEC:CAL:SENsor" command. The TEC display will show the resistance value. The LDC-3900 will beep when it is ready to accept a new calibration value.

   If this value is to be measured and entered remotely via a GPIB controlled DMM, for example, the measured value of the resistance should not be entered until the LDC-3900 is ready to receive it.

   The LDC-3900 will be ready to receive the resistance value when, after a "TEC:CAL:SEN?" query is sent, the response from the LDC-3900 is "1".

e. Input the actual resistance (in kΩ) measured by the external DMM (as an <nrf value>) via the "TEC:R <nrf value>" command.

   After the "TEC:R" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the expected "TEC:R" value is entered, or the system will "hang". This happens because the LDC-3900 will wait indefinitely for an input, yet not allow any input until the calibration is finished.

f. Once the "TEC:R" value is sent, the LDC-3900 will beep and return to its former state (before calibration). The "OPC?" query may be used (after the "TEC:R" value is sent) to determine when the calibration is completed.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

g. Switch the THERM RANGE switch (back panel) to the 10 μA position and repeat this procedure with the other resistor.

5.5.3 Local Operation ITE Current Calibration

The following procedure is for calibrating the ITE constant current source for both polarities of current. This procedure calibrates the zero current set point automatically, then it automatically drives the TE current output to internally set limits of ±1 amp. When each of these values is reached and is stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3900 then automatically calibrates the TEC current source and limits.

This procedure is for local (front panel) operation. See Section 5.5.4 for remote calibration of the ITE current.

a. With the output off, connect a 1 Ω, 10 W resistor across the TEC output terminals (on the TE OUTPUT connector, see Figure 4.1) and use a calibrated DMM to measure the voltage across the resistor.

Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

-where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. (A 4-point probe resistance measurement is recommended.)

Select the LCM-39420 for calibration by pressing the appropriate (ADJUST) LAS/TEC switch (so that the TEC indicator is orange). If the TEC output is not off, the TEC current calibration mode cannot be entered.

b. Press the (GPIB) LOCAL and (TEC DISPLAY) ITE switches at the same time to place the LCM-39420 in its TEC Current Calibration mode. The OUTPUT must be off to enter the TEC calibration mode. The LDC-3900 will automatically turn the LCM-39420 OUTPUT on during calibration, when it is required.

The TEC display will show a value of about zero amps as the LCM-39420 calibrates itself for a zero current level. After about 20 seconds the LDC-3900 will beep and the TEC display will begin to change to show about 1 amp, for calibration.

c. After the value on the TEC display is stable (has not changed by more than one digit for several seconds) the LDC-3900 is ready for the actual I value to be entered.

Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display shows the correct value, as calculated from Step a.

d. Release the (PARAMETER) SET switch to store the new calibration value into non-volatile memory on the LCM-39420. The LDC-3900 will then beep to indicate that it is ready for the user to enter the calibration value for its negative polarity output.

e. Repeat Steps c and d for the negative polarity of the TEC output current. After the value for the negative polarity of the TEC output is entered, the LCM-39420 will automatically calibrate its current limits and set points. After a few seconds, the LDC-3900 will return to its former state (before calibration). The LDC-3900 will beep when it has finished storing all of the new calibration values.

5.5.4 Remote Operation ITE Current Calibration

The following procedure is for calibrating the ITE constant current source for both polarities of current. This procedure calibrates the zero current set point automatically, then it automatically drives the TE current output to internally set limits of ±1 amp. When each of these values is reached and is stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3900 then automatically calibrates the TEC current source and limits.

This procedure is for remote (GPIB) operation. See Section 5.5.3 for local (front panel) calibration of the ITE current.

a. With the output off, connect a 1 Ω, 10 W resistor across the TEC output terminals and use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

-where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. (A 4-point probe resistance measurement is recommended.)

b. Enter the "TEC:CHAN x" command over the GPIB to select the channel of the LCM-39420 to be calibrated, where x = the channel number. Enter the "TEC:OUTPUT OFF" command to force the output off.

Enter the "TEC:CAL:ITE" command over the GPIB to place the LCM-39420 in its TEC Current Calibration mode. The LDC-3900 will automatically calibrate its zero output current and beep when it is ready to continue. If the TEC output is not off, the TEC current calibration mode cannot be entered.

The LCM-39420 will first perform a zero point calibration. This takes about 20 seconds. Then it will set the output to 1 Amp, for calibration.

c. When the LDC-3900 is ready for the actual TEC current value to be entered, a remote query of "TEC:CAL:ITE?" will return a response of "1".

When the measured value (actual ITE) is stable and the LDC-3900 is ready to proceed, enter the value by issuing the "TEC:ITE <nrf value>" command, where the absolute value of the actual ITE measurement is the <nrf value>.

To ensure measurement stability of the actual I value when the measurement is taken as a part of an automated test, the DMM measurement should be polled in a loop. When the measured value is consistent within one digit for 5 seconds (for example), the actual I value could be considered stable.

d. Once the actual ITE value is entered via the "TEC:ITE" command, the new calibration value is stored into non-volatile memory on the LCM-39420. The LDC-3900 will then be ready for the user to enter the negative calibration value.

e. Repeat Steps c and d for the negative polarity of the TEC output current (entering the absolute value of the measurement). After the value for the negative polarity of the TEC output is entered, the LCM-39420 will automatically calibrate its current limits and set points. After a few seconds, the LDC-3900 will return to its former state (before calibration). The LDC-3900 will beep when it has finished storing all of the new calibration values.

After the last "TEC:ITE" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the last "TEC:ITE" value is entered, or the system will "hang". This happens because the LDC-3900 will wait indefinitely for an input, yet not allow any input until the calibration is finished.

If the "*OPC?" query is issued during ITE calibration, the time out period of the GPIB driver should be at least 1 minute to prevent the GPIB driver from timing out and "hanging" the system. Refer to your GPIB driver instruction manual for information on setting the GPIB driver time out period.

The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.